

Introduction to CBM Development and Utilization of Jincheng Anthracite Mining Group

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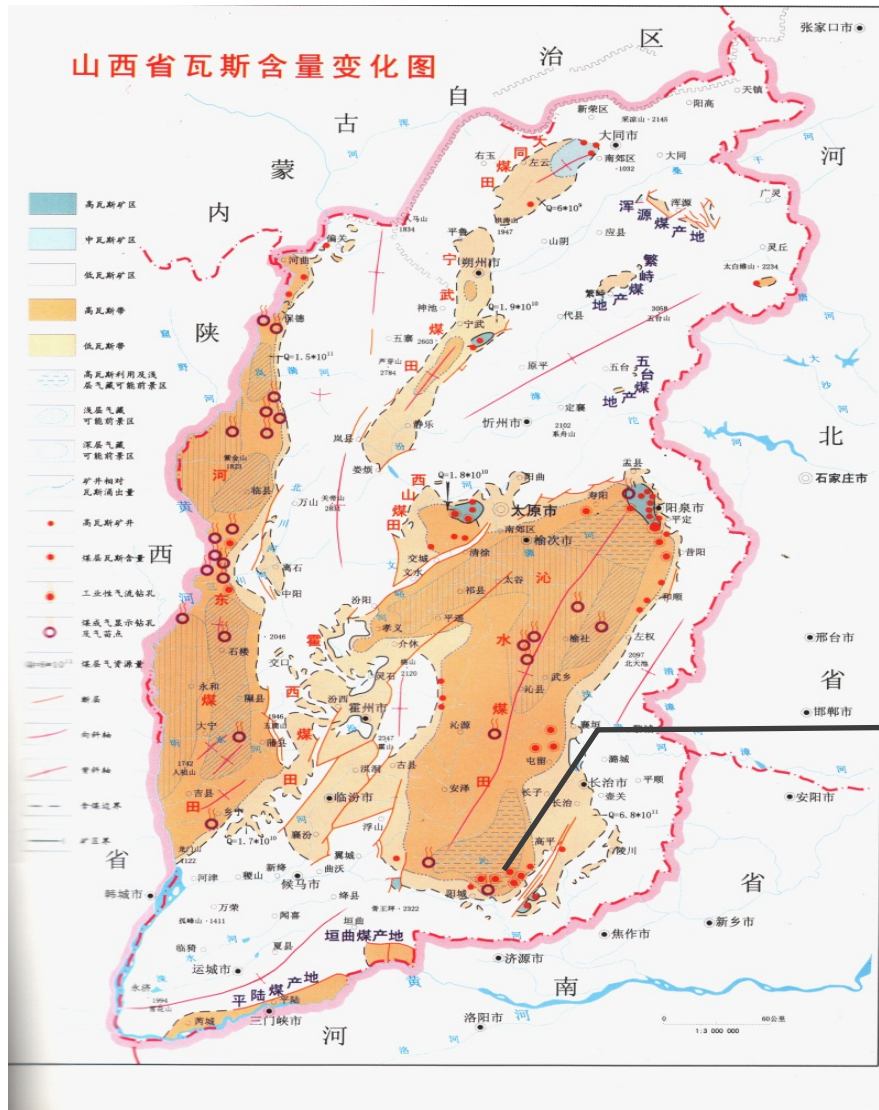
Outline

JAMG Profile and Background of Integrated Coal Mining and Gas Extraction Development

Practices of Integrated Coal and CBM Mining Development Technologies in Jincheng Coal Mining Area

Theory and Technical System of Three-zone Integrated Mining in Coal Mining Area

JAMG CBM Comprehensive Utilization Situations



•Jincheng Mining Area locates at southeast edge of Qinshui Basion, Shanxi Province, west wing of south section, Taihang Mountain compound anticline

JAMG

JAMG is an important production base (60 million ton/a) of quality anthracite in China, the largest coal chemical industry group (14 million ton/a), the largest CBM extraction enterprise, and the largest coal-mine gas power generation group in China.

No. **379** of 2015 World Fortune 500

No. **78** of 2014 China Enterprises TOP 500

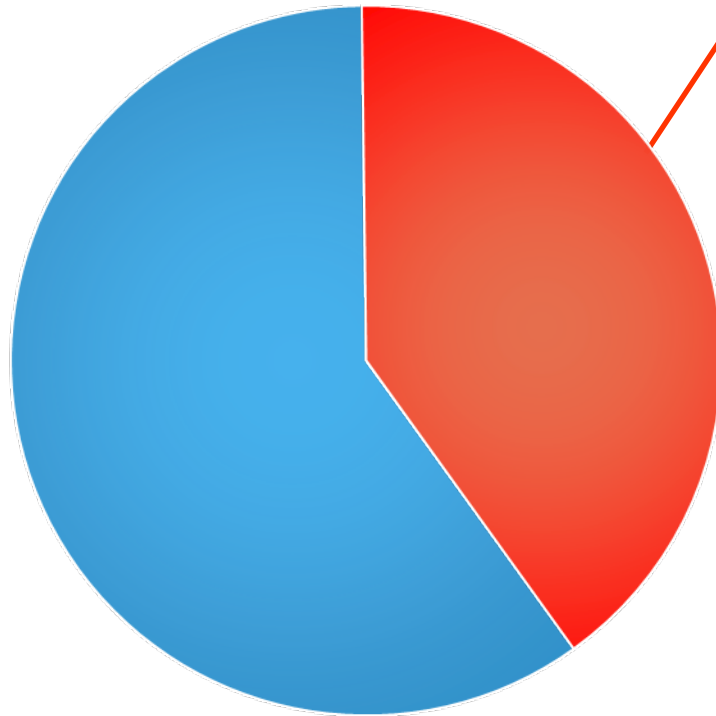
No. **9** of 2014 China Coal Industry Enterprises TOP 100



JAMG main producing mines are high-gas mines



63 Mines

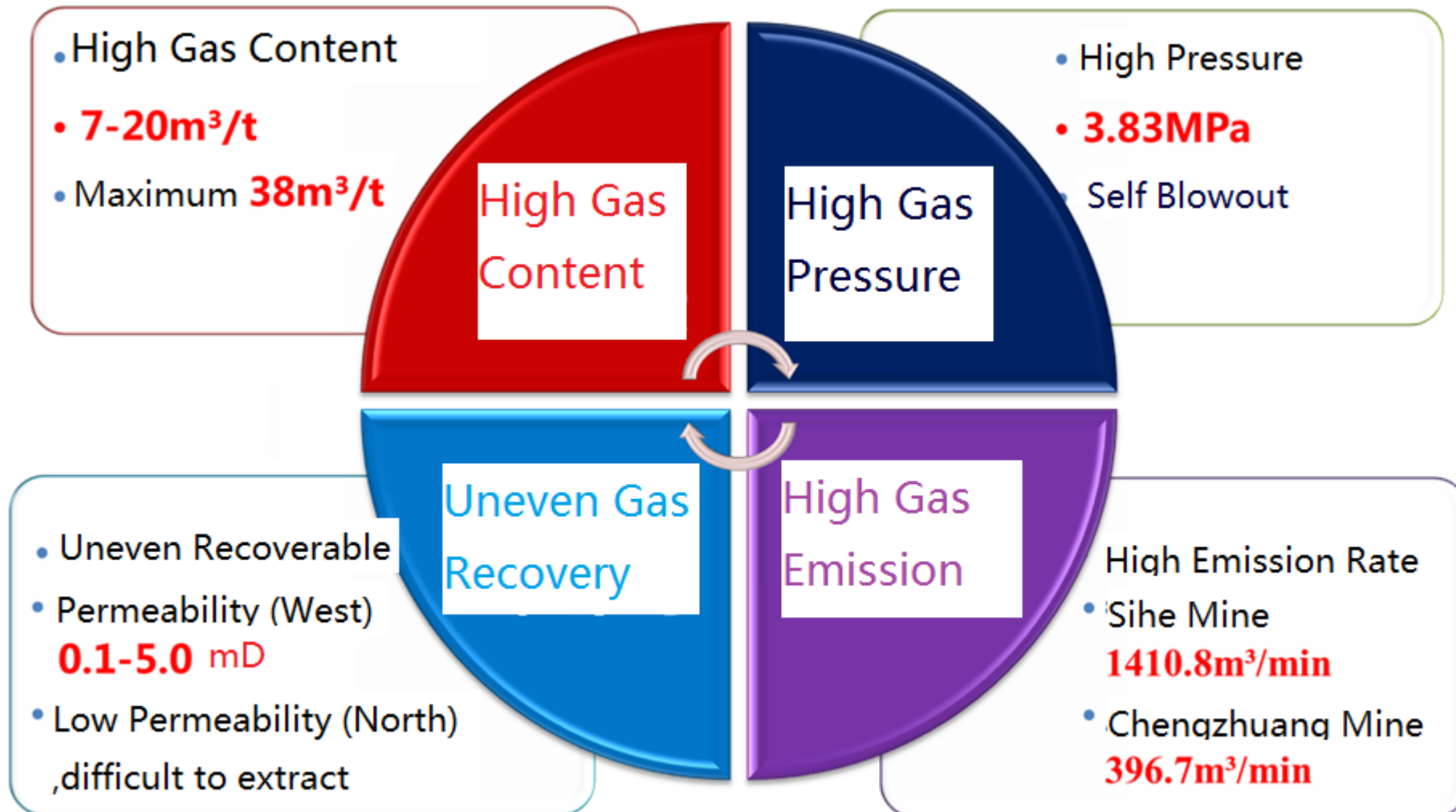


22 High-gas and outburst mines

- Main coal mines are distributed in Jincheng, Changzhi, and Linfen, and mining depth is from **100m** deep to **800m**. The proportion of high-gas mine to total coal output of the group reaches up to **86%**.
- Accumulatively **650 Million ton** raw coals are produced

Gas is the **greatest threats** to safety production of coal mine

Four characteristics of coal mine gas in Jincheng Mining Area



Gas is the primary factor restricting efficient and safe production of mines



Since the end of 1980s, leaders and employees of JAMG started to realize that **gas is the primary factor restricting efficient and safe production of JAMG mines.** Through over 20 years' production practices and exploration, and after solving difficulties such as CBM ground extraction, underground efficient extraction and integrated extraction in anthracite coal mining area, JAMG creates a way of coal and CBM safe, efficient and coordinated development.



- **Through over 20 years' exploration and development, by 2014, total volume of JAMG ground and underground gas extraction reached 2.543 Billion m³, and total utilization of ground and underground gas reached 1.711 Billion m³, in which, the ground CBM extraction in 2014 is 1.43 Billion m³, and utilization is 1.104 Billion m³, accounting for 40% of total extraction and utilization in China, and forming the largest CBM development and utilization market in China.**
- **In the recent ten years, JAMG accumulatively extracted 14.047 Billion m³ CBM, and utilized 8.418 billion m³ CBM, equaling to reducing 1.26ton carbon dioxide emission; meanwhile, the mine safe production level improved greatly.**

II. Practices of Integrated Coal and CBM Mining Development Technologies

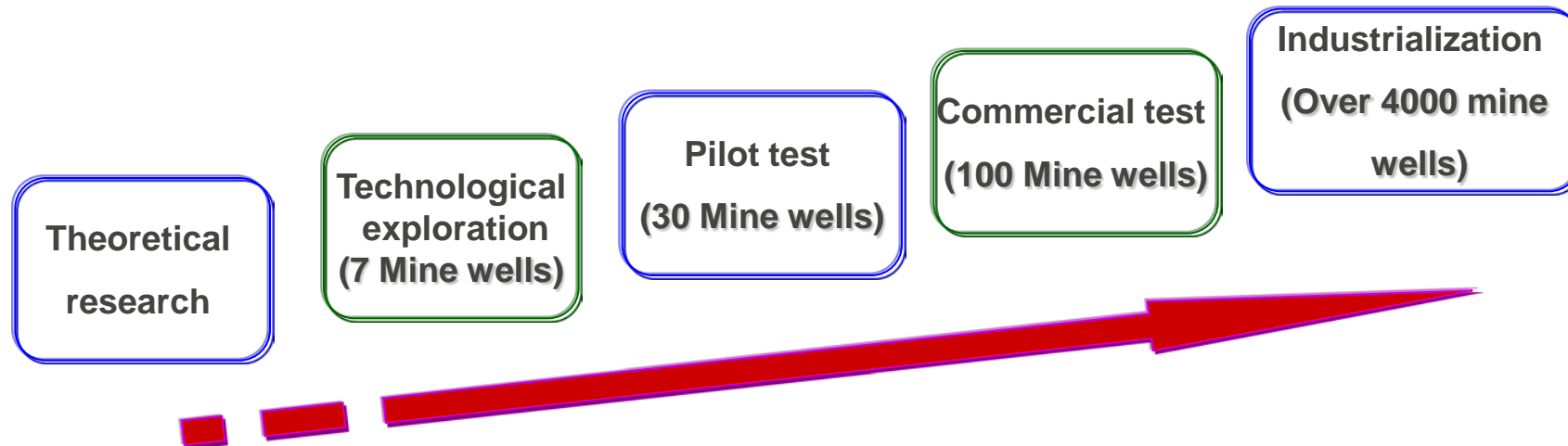
Insist on scientific innovation, realize coal-mine gas ground extraction the earliest



As early as the beginning of 1990s, Jincheng Mining Bureau, the predecessor of JAMG, introduced ground CBM extraction technology from USA to carry out mine group development test for 7 mine wells in Panzhuang Mining Area, and firstly gained a series of results such as “water drilling, active water fracture, constant pressure drainage, low-pressure gathering and transportation” in Qinshui Basin, laying technical foundation for successful ground extraction of CBM in Qinnan area



Development history



Through continuous difficulty solving and innovation in five stages including ground mine well extraction theoretical research, preliminary attempt of 7 mine wells, guiding test for 30 mine wells, commercial test for 100 mine wells and scale extraction, JAMG formed a set of low-cost and high-efficient ground extraction technology.

1. Ground pre-extraction technology



JAMG developed key technologies such as water drilling, active water fracture, constant pressure drainage, low-pressure gathering and transportation in Jincheng mining area, and formed a complete set of ground CBM development technology system; firstly realized CBM scale extraction in China, and probed new effective approach for industrial development and coal-mine gas treatment.

The research findings won the second prize of National Science and Technology Progress Award



Cluster well mining technology

JAMG improved, innovated the original vertical well mining technology, and formed cluster well mining technology under different geological conditions in Jincheng Mining Area, which has been applied extensively in Hudi and Zhengzhuang



Break through CBM ground extraction technology in mining area

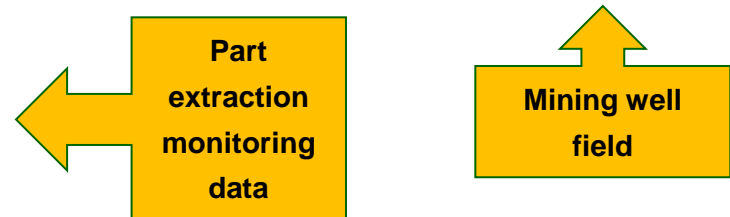
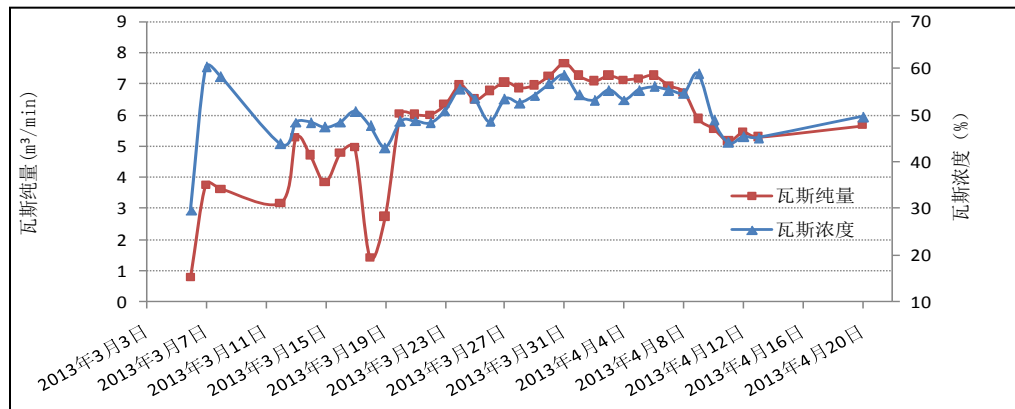


Chengzhuang Mine CZCD-01 ground extraction gained great breakthrough:

(1) The extraction concentration in gob reached over 50%, Average scalar extraction quantity is 6000m³/d, and maximum quantity is 10000m³/d. The total extraction has reached 2 million m³

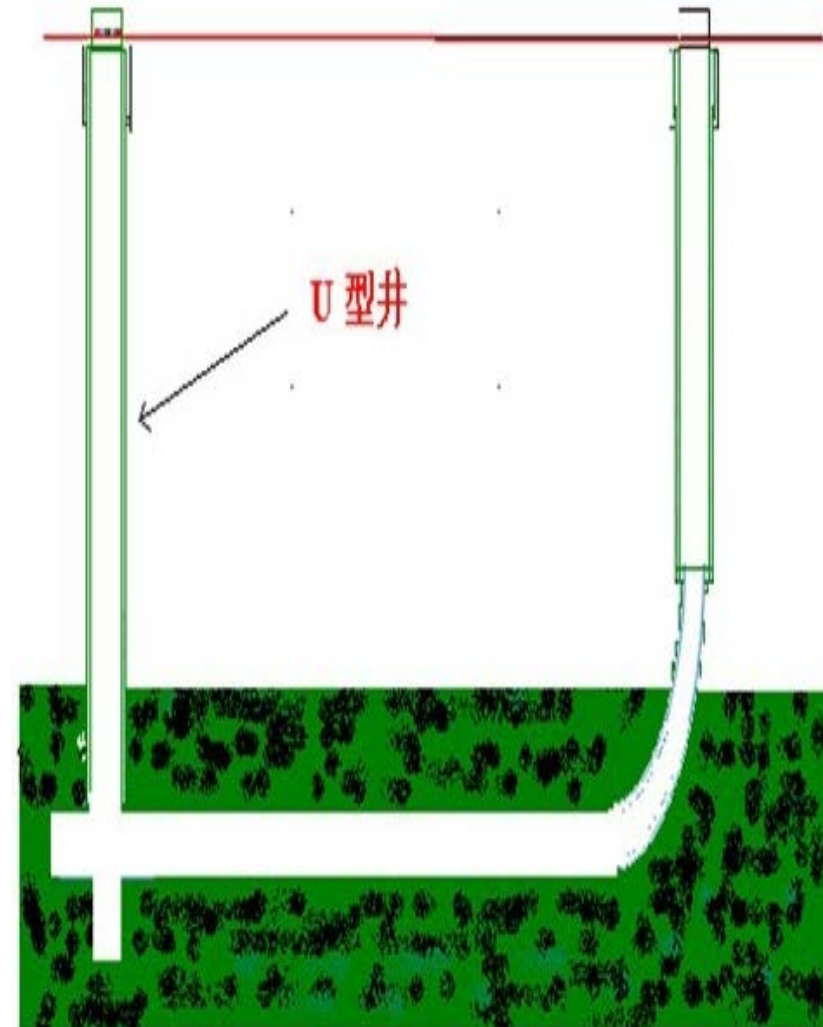
(2) Realized continuously extraction in affection zone and gob, and excessive gas on working surface was eradicated completely

News Report of MOST



Soft low permeability coal bed U-type butt joint, staged fracturing process

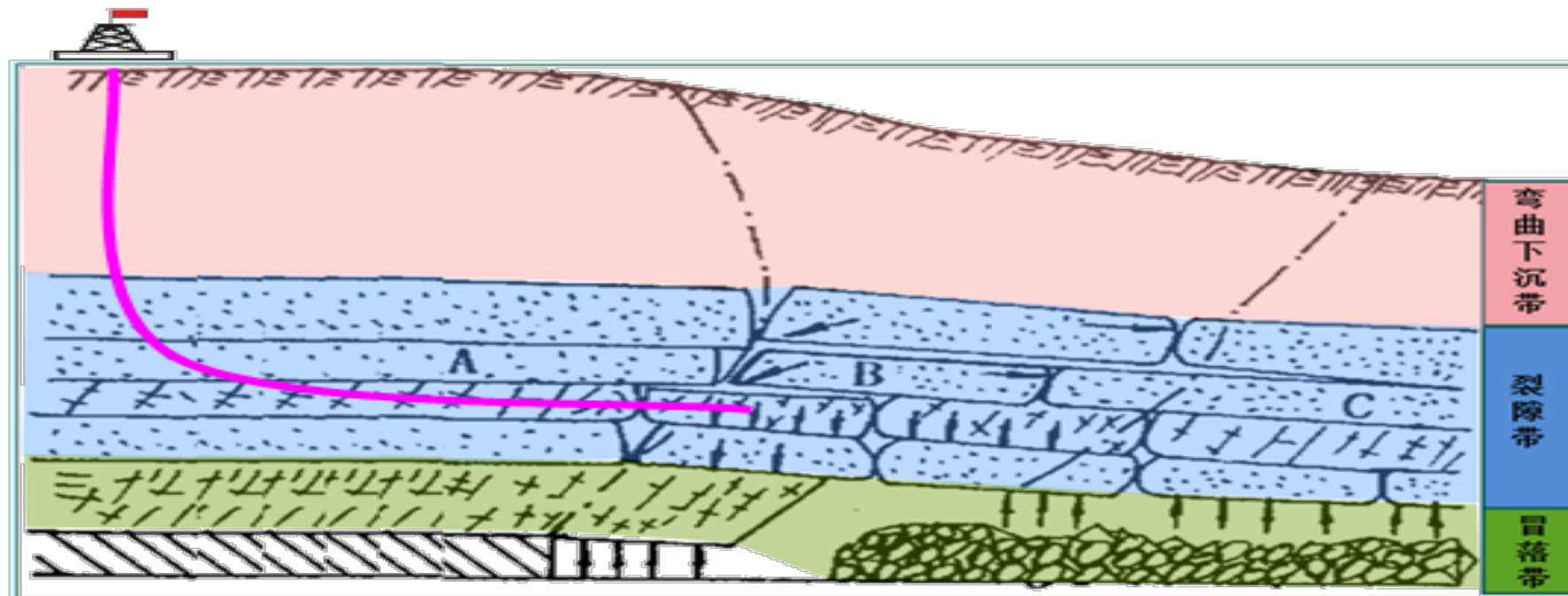
- “U” type well has advantages of small land area, and favorable permeability effect;
- Constructed two wells for medium and hard coal seam in Sihe Mining Area with maximum daily gas output of 20000m³;
- At present, 10 wells have been constructed in crushed and soft coal seam in Zhaozhuang and Changping, with single well coal seam section footage of 800m, among which, the first well in Erpan Zone, Zhaozhuang Mine has maintained daily output over 5000 m³ for 15 consecutive months



Initiate L-shape well mining technology in mining area



Sihe 3313 working surface SH14-L-01 well was finished drilling on July 10, 2014; the well depth is 1271.67m. After well completion, and under mining function, the maximum extraction of the well reached 32000 m³/day, and maximum concentration reached 96%, providing favorable guarantee for safe and efficient production of 3313 work surface.



2.Underground area mining technology



JAMG developed key mining technologies such as **1000m directional long drilling hole, and regional progressive**, and formed a complete set of underground methane mining technology system.

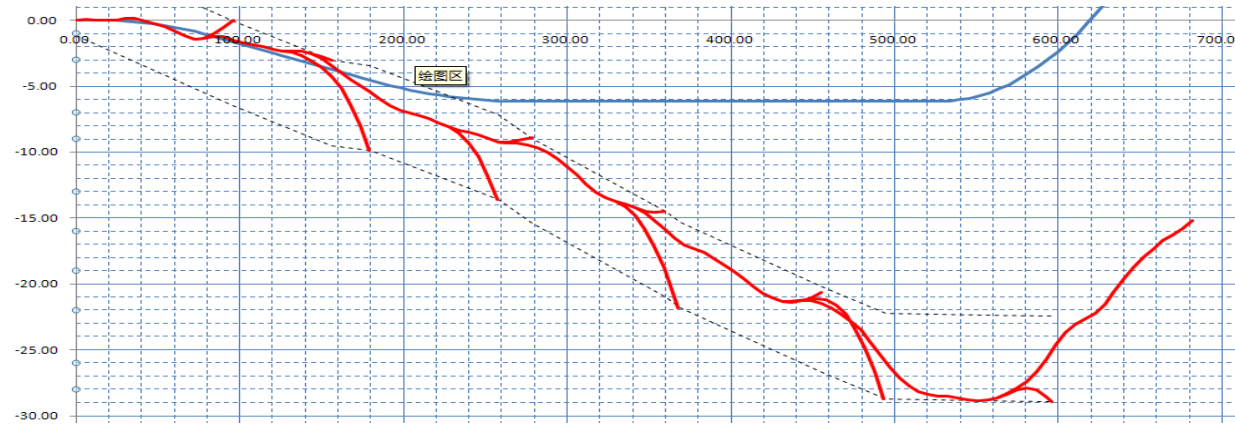
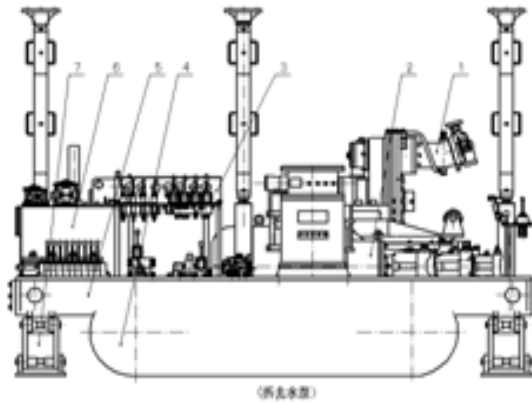
2.1 Underground 1000m long hole directional drilling technology

2.2 Regional progressive mining technology

2.1 Underground 1000m long hole directional drilling technology



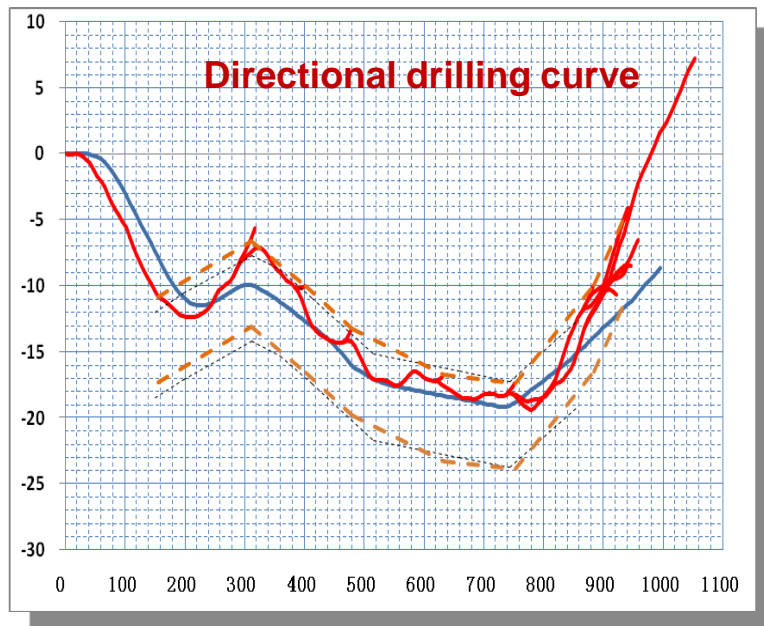
By domestic drilling equipment and MWD apparatus, JAMG formed underground coal seam 1000m hole directional drilling technology with maximum horizontal hole depth of **1881m**(bore diameter **96mm**), effective extraction drilling hole length of coal seam dendritic (including main hole and branch hole) of **2000~5000m**.



2.1 Underground 1000m long hole directional drilling technology



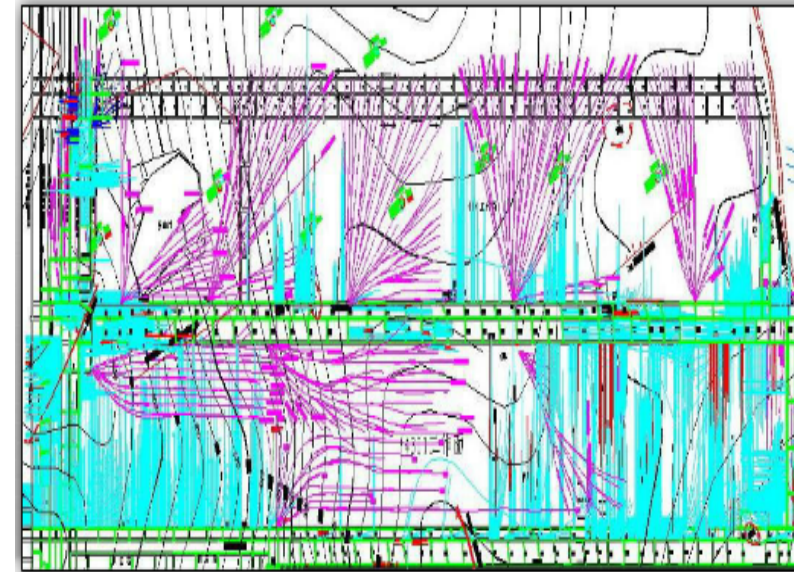
1000m Driller is promoted since



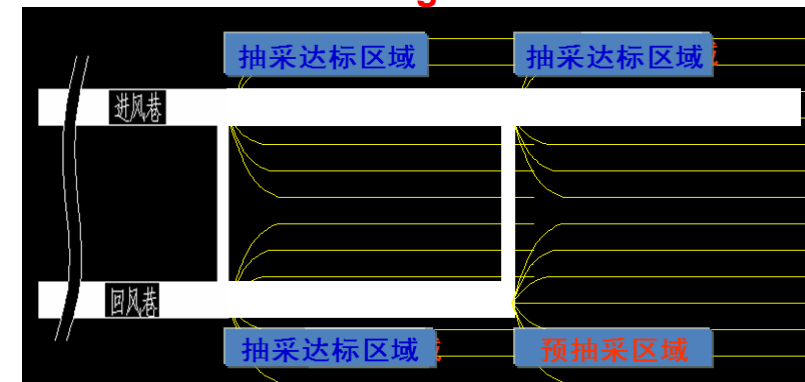
- ❑ Driller monthly efficiency reached **8000-10000m/set**
- ❑ Single hole length reached **1881m**
- ❑ Dendritic hole length reached **2000 ~ 5000m**
- ❑ Gained favorable effect of **“complying with outburst prevention standard, gas concentration limit, accurate geological structure and double footage”**

2.2 Regional progressive gas mining technology

The technology extracts progressively from shallow to deep coal seam, from low gas to high gas zone and from work surface of prior stage to next work surface, effectively reduces CBM content, lay favorable foundation for safe and rapid mining and effective recovery of work surface coal seam lane, and meanwhile greatly reduces ventilation air methane content in mine.



Progressive drilling hole layout in Sihe Mining Area



Sketch map of stripe progressive mining

2.2 Regional progressive gas mining technology

All outburst coal mines are built with ground pump equipped with large capacity water-ring vacuum pump. Each pump station is built with double-extraction system or multiple-extraction system for high and low concentrate gas extraction.

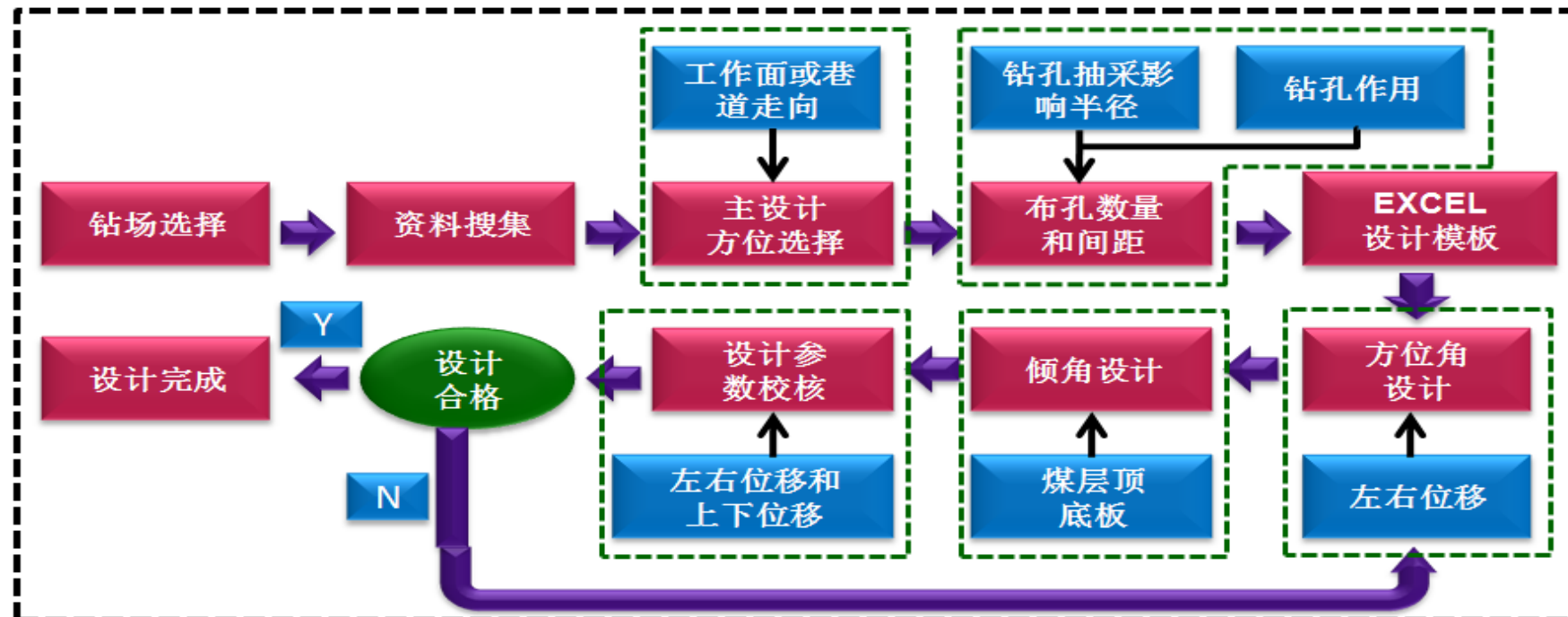
There are 5 pumps in East and West wells of Sihe Mine, with annual extraction capacity of **650 Million m³**.



Optimized medium hard coal seam drilling hole extraction process technology



Perfect quasi-horizontal directional drilling hole optimal design method, and optimize design process combining coal seam direction, extraction radius and geological condition to make drilling construction more efficient and accurate.



3. Ground and underground integrated extraction technology



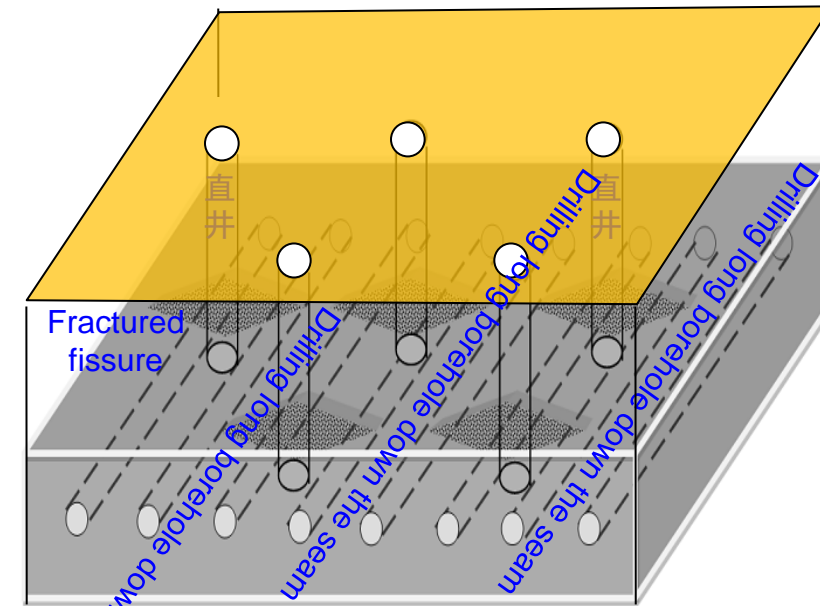
JAMG insists on independent innovation, carries out study on CBM scale mining and coal-CBM integrated mining, plays respective advantages of ground and underground mining in preparation area, creates ground and underground integrated extraction technology, and greatly improves CBM extraction speed and CBM extraction rate.

3.1 Ground and underground integrated extraction technology

3.2 CBM ground mining technology in mining area

3.1 Ground and underground integrated extraction technology

In mining preparation zone, the stereo extraction network contracted by drilling long borehole down the seam and fracture fissure is formed by penetrating ground shaft fracture fissure and affected zone of drilling long borehole down the seam constructed underground, so as to realize regional relieved extraction, greatly improve extraction efficiency and shorten standard reaching time.

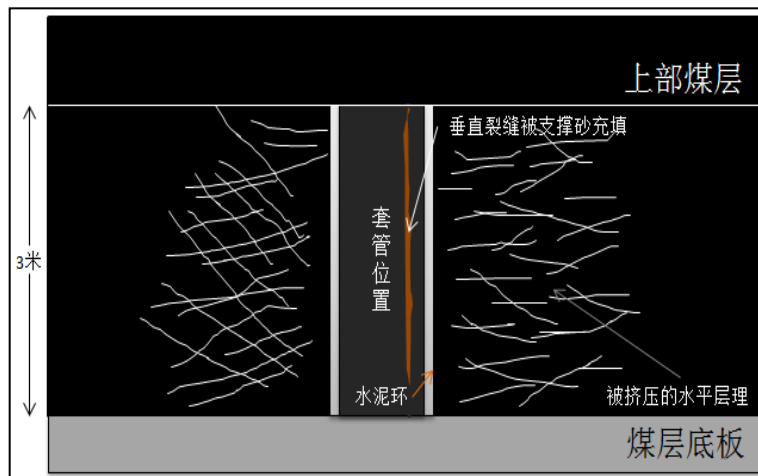


Sketch map of ground and underground integrated extraction

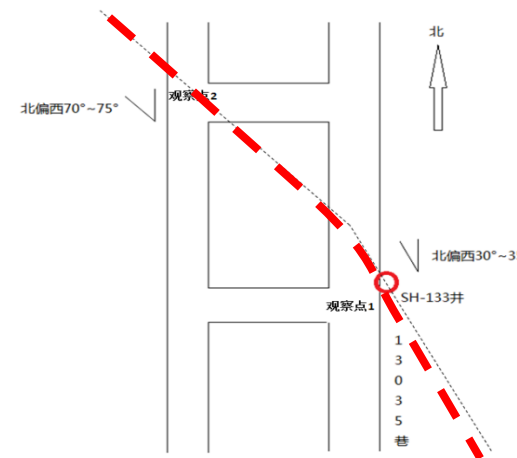
3.1 Ground and underground integrated extraction technology



By directly disclosing and observing ground shaft fractured fissure characteristics underground, vertical fractures may be formed when burial depth is less than **600m(300-600m)**



Underground observation of SH133 well fractured fissure
Profile Map
(Yellow line is the fracture supported by silica sand)



Underground observation of SH133 well fractured fissure
Plane projection map
(Red line is the fracture supported by silica sand)

3.2 CBM ground mining technology in mining area

Construct shaft or horizontal well in coal mining area by coal seam relief effect to improve CBM development and gas treatment effect; the accumulated single mine gas output is over **2 million m³**, which can effectively CBM extraction amount, reduce ground extraction cost and meanwhile solve the problem of exceeding corner gas on recovery work surface.

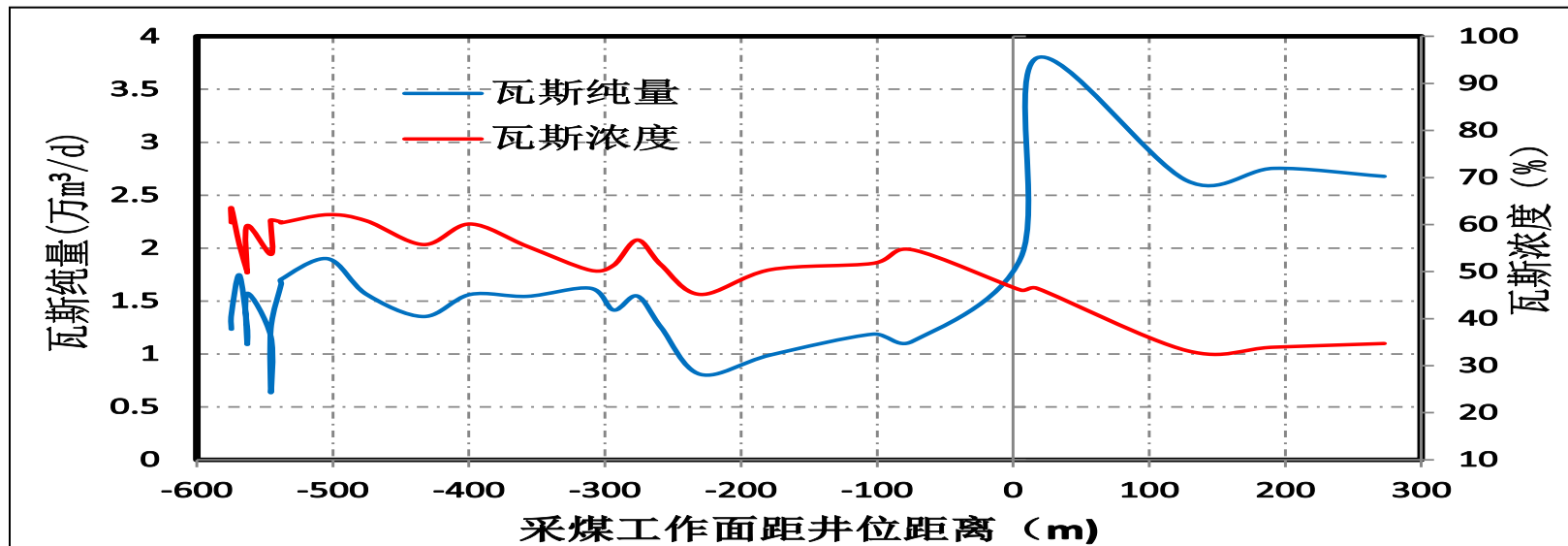


3.2 CBM ground mining technology in mining area



The mining effects in Chengzhuang Mine 5310 work surface CZCD-01 ground well mining zone are outstanding

- (1) Realized continuous mining in this coal mining zone, and after coal mining, the mine well structure keeps in good condition;
- (2) Drainage concentration is as high as **86%**;
- (3) Scalar extraction quantity is about **10000m³/d**, and total extraction amount has reached over **2 million m³**;
- (4) Effectively ease the gas treatment pressure on work surface 5310 and W2301



III. Theory and Technical System of Three-zone Integrated Mining in Coal Mining Area

Classification principle of “Three Zones” in coal mining area



- Based on space-time alternation rules of coal mining, the coal mining area is divided into coal production planning zone (hereinafter referred to as planning zone), coal mining preparation zone (hereinafter referred to as preparation zone) and coal mine production zone (hereinafter referred to as production zone). The production zone is existing production area of coal mine, preparation zone is coal mine which will produce recently (generally to be recovered in 3 – 5 years), while the planning zone is the area where coal resources will be mined generally in 6 – 15 years or even longer with sufficient CBM pre-extraction time.

Ground pre-extraction zone

(Coal mine planning zone)

**Ground and
underground
integrated mining
zone**
(Mine preparation
zone)

**Underground
mining zone**

(Coal mine
production zone)

Mathematical model of maximum allowable gas content for safety coal mine production

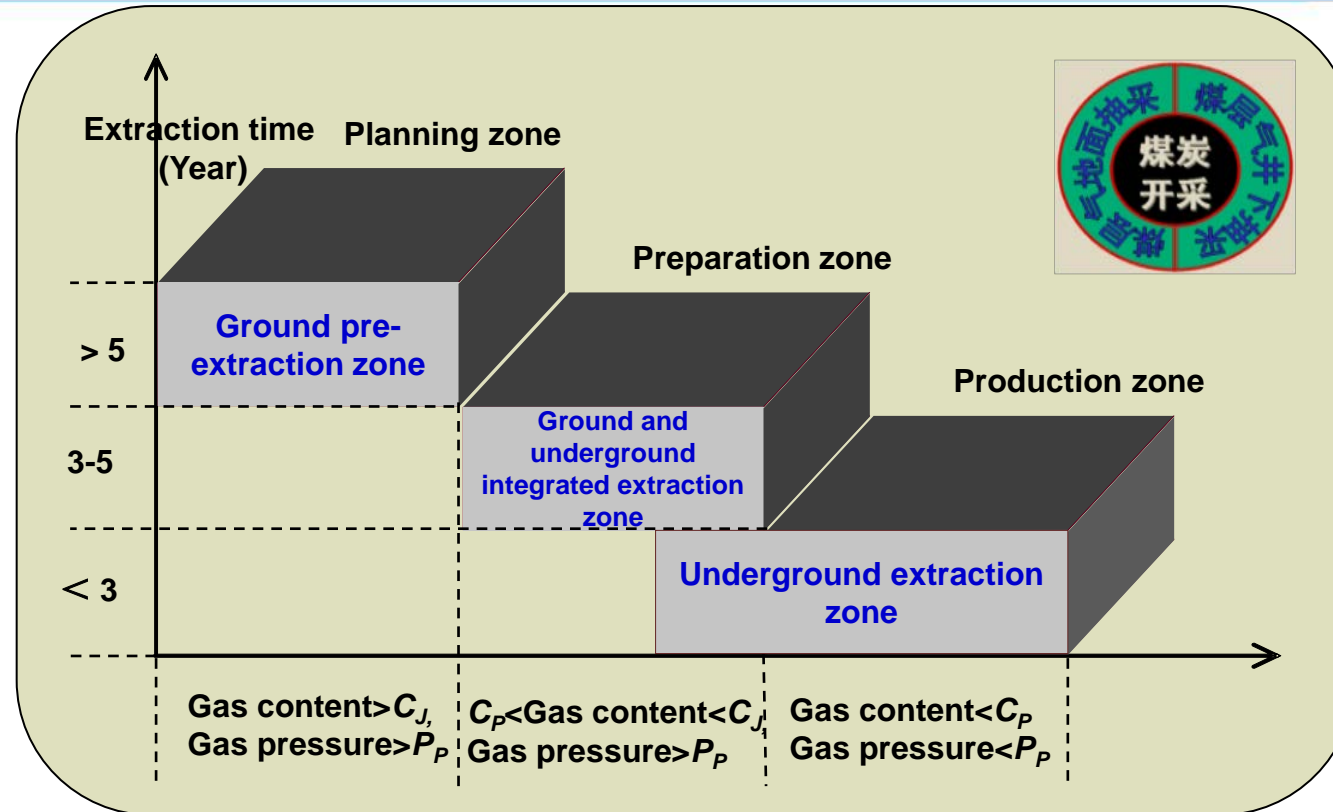


- According to CBM geological characteristics, gas geological conditions, coal mining strengthen and coal mine ventilation safety measures, the mathematical model of coal mine allowable gas content for safe production can be deducted, which provides reference for decision making about gas content threshold for “three-zone” integrated space-time alternation (when coal production enters next space from the previous one):

$$C_p = C_{ic}(1 - R) + \beta \varepsilon \frac{M_c \times S_h \times V_h}{nP}$$

- In the formula : C_p , allowable CBM content, m³/t; C_{ic} , original gas content per ton coal, m³/t; R , methane desorption rate , %; β , coal resource recovery rate , %; ε , comprehensive influence factor ; M_c , allowable methane concentration in return current , %; S_h , Return way sectional area , m²; V_h , return way maximum wind speed , m/s; P , Coal output per unit time , t/s; n , Ratio between work surface head affected distance and work surface advance speed

Theory and Technical System of Three-zone Integrated Mining

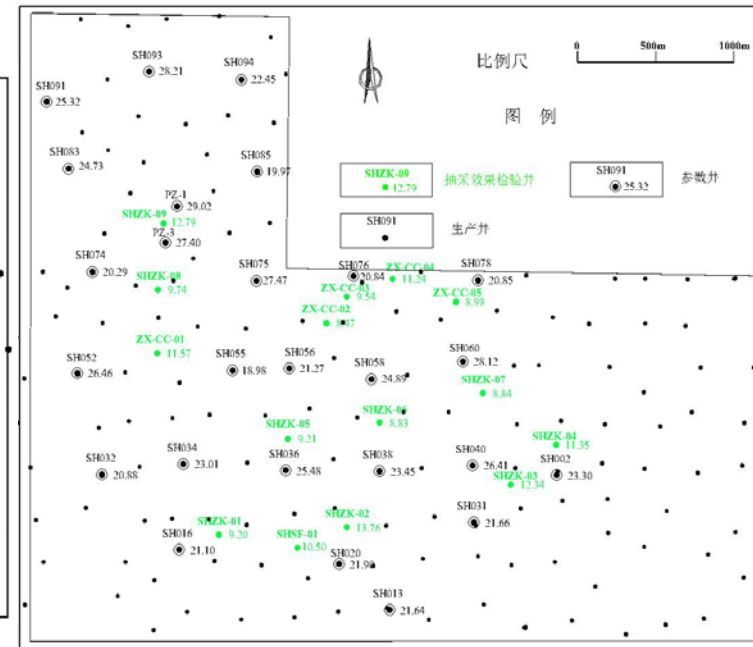
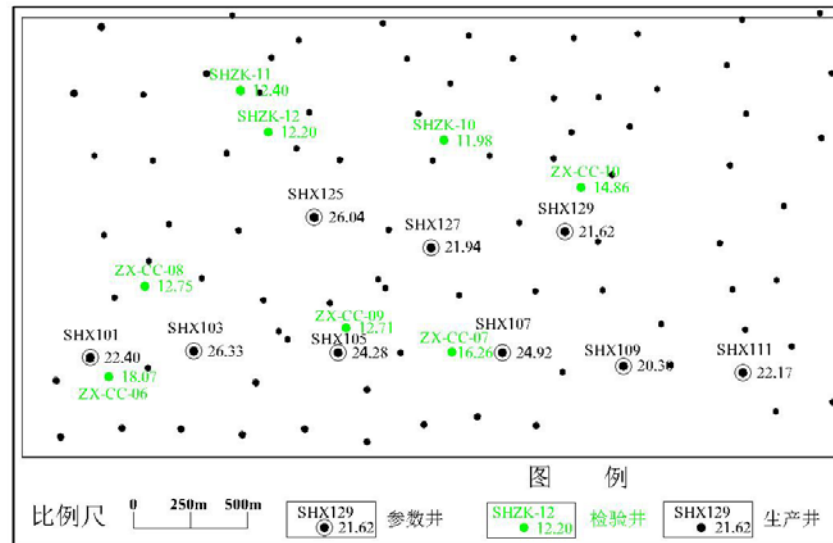


The overall of three-zone integrated mining deduced is confirmed by aforesaid formula; different technical measures shall be adopted for different zones so as to realize safe, efficient and coordinated development of CBM and coal mining, and realize gas-coal integrated mining.

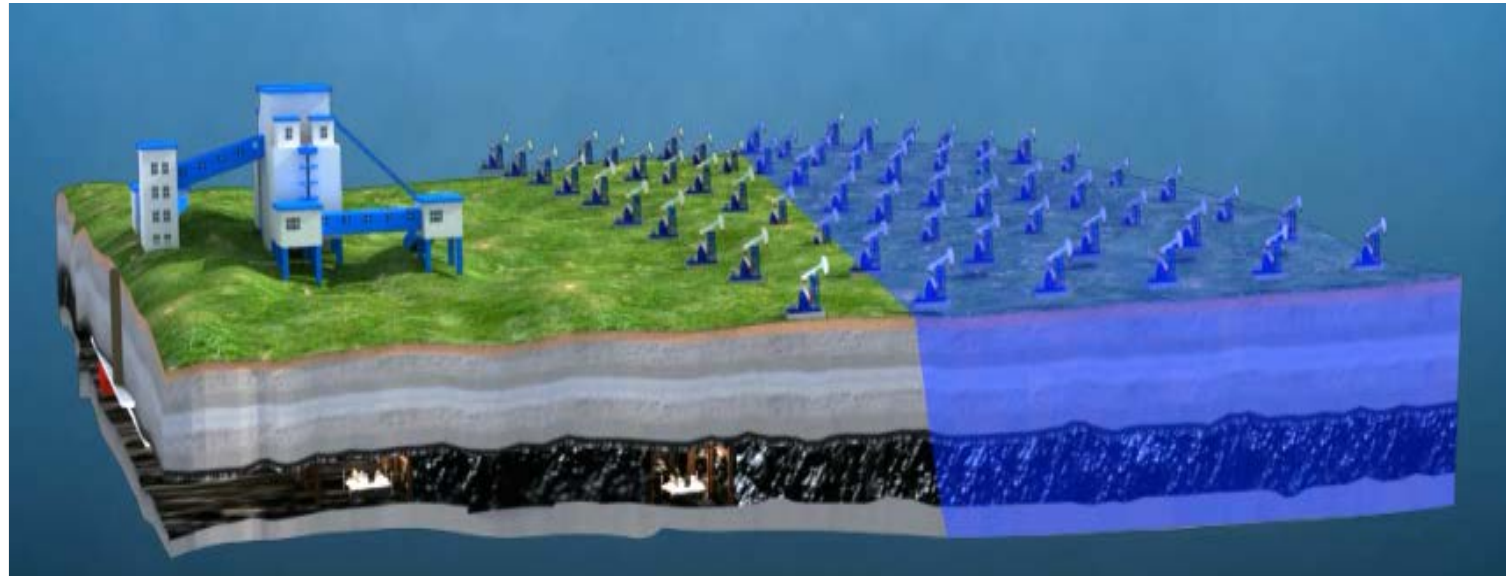
Three-zone integrated ground and underground mining mode in Jincheng Mining Area



★ **Coal mine planning zone** can carry out maximum pre-extraction by means of ground shaft, cluster well and horizontal well, and realize effective and coordinated development of coal and CBM. According to verification results of Dongwupan Zone, Sihe, the pre-extraction shall be carried out 15 days in advance.



Extraction technology in planning zone



Planning zone

Mining zone in next **6 years or longer**——

Carry out pre-extraction by means of **ground shaft, cluster well and horizontal well**

Extraction technology in planning zone

Actual effect of ground mining in planning zone



20m³/ton
High gas

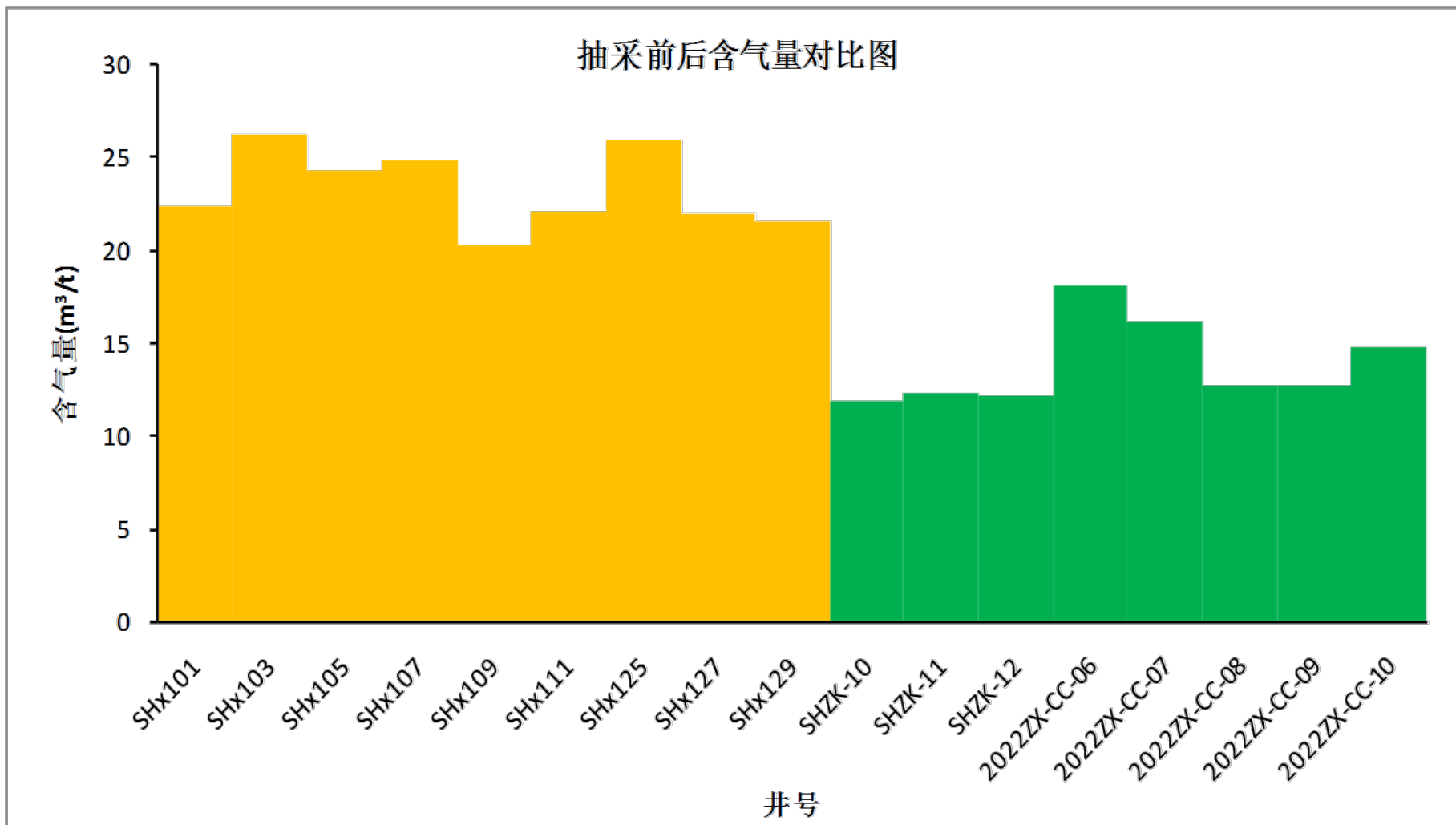
10
Years

10m³/ton
Reaching
standard

Construct **10 mine wells** per
square kilometer

Preliminary gas content may
reduce **1.5m³/ton** every year

Extraction technology in planning zone



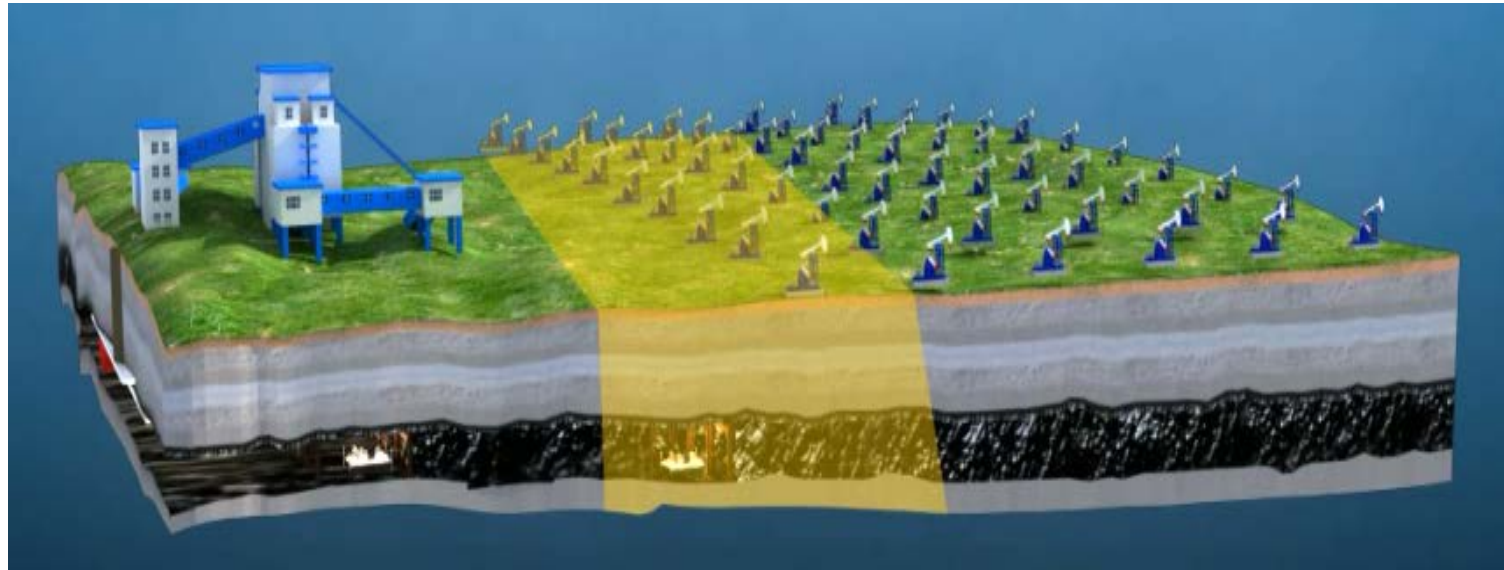
Three-zone integrated ground and underground mining mode in Jincheng Mining Area



★ **Coal mining preparation zone:** generally transferred to coal production zone in 3 – 5 years; for over five years, the maintenance cost shall be increased; while for over short time, gas content and gas pressure may fail to reach standard due to insufficient methane desorption rate

★ JAMG initiated the **ground and underground integrated extraction technology**, which sufficiently play the advantages of “ground fracture ” and “underground directional long drilling hole” , and creates conditions for accelerating transferring preparation zone to production zone.

★ According to the extraction effect of Sihe mine, the extraction time of preparation can shorten about 50%.

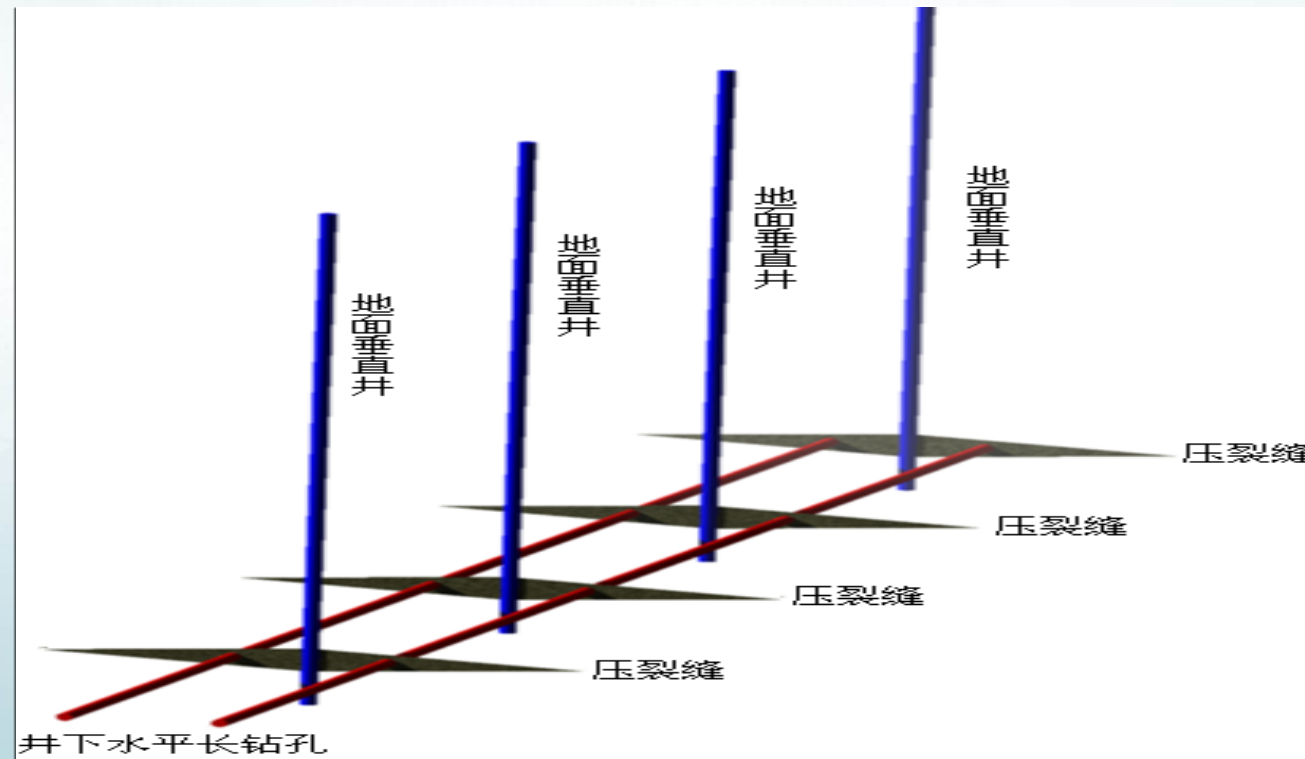


Preparation zone

Recover in **3—5 years** ——

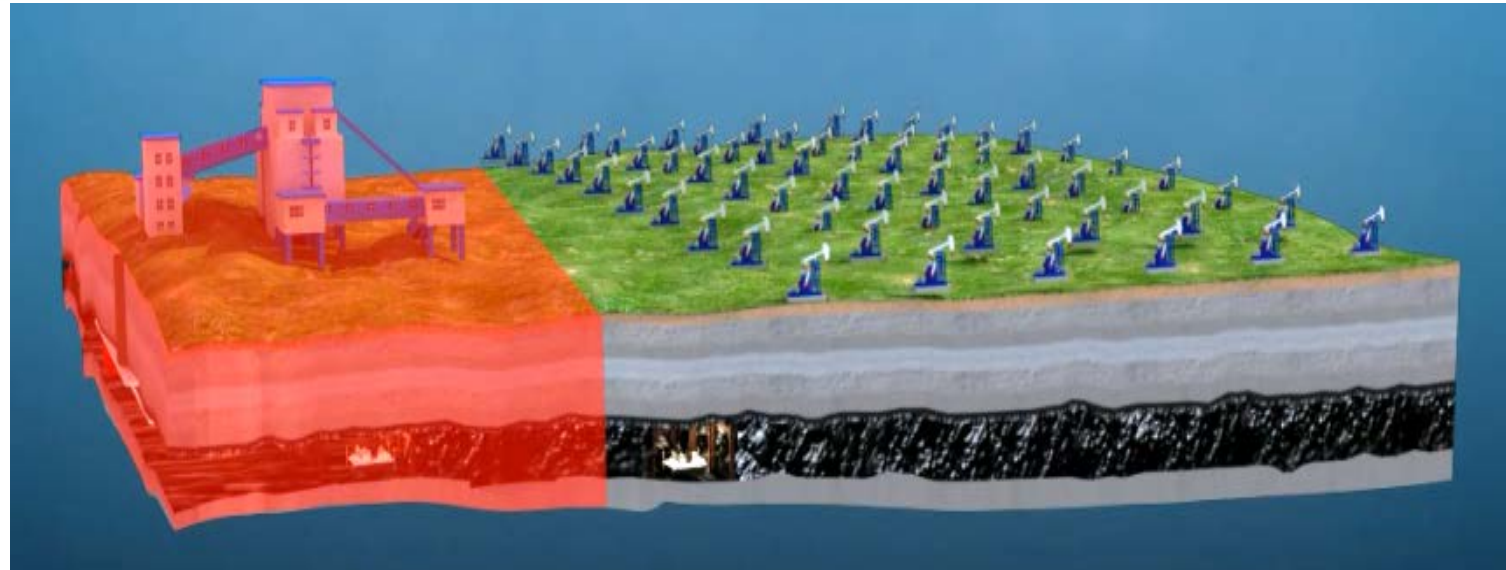
Play the advantages of “**ground fracture**” and “**underground directional long drilling hole**” technologies, and adopt the new technology of **ground and underground integrated extraction** for pre-extraction so as to greatly improve extraction efficiency and shorten standard reaching time.

**Realize ground and underground integrated extraction ,
accelerating gas extraction progress**



Combine advantages of “**ground fracture**” and “**underground directional long drilling hole**” technologies

Extraction technology in production zone



Production zone

Existing production area of coal mine——

For ground mine well, implement extraction in mining area and the gob; for underground mine well, arrange drilling borehole down the seam, to effectively reduce gas emission rate during mining, eliminate weakness left by anisotropy of gas occurrence, and strengthen final gas extraction effect.

Three-zone integrated ground and underground mining mode in Jincheng Mining Area



▲ **In coal production zone**, although regional extraction standard has reached, in order to guarantee safe and efficient coal mine production, the drilling borehole extraction on the bad seam shall be carried out.

▲ **Meanwhile, CBM ground mining technology in mining area** can be applied to production zone to improve CBM extraction rate

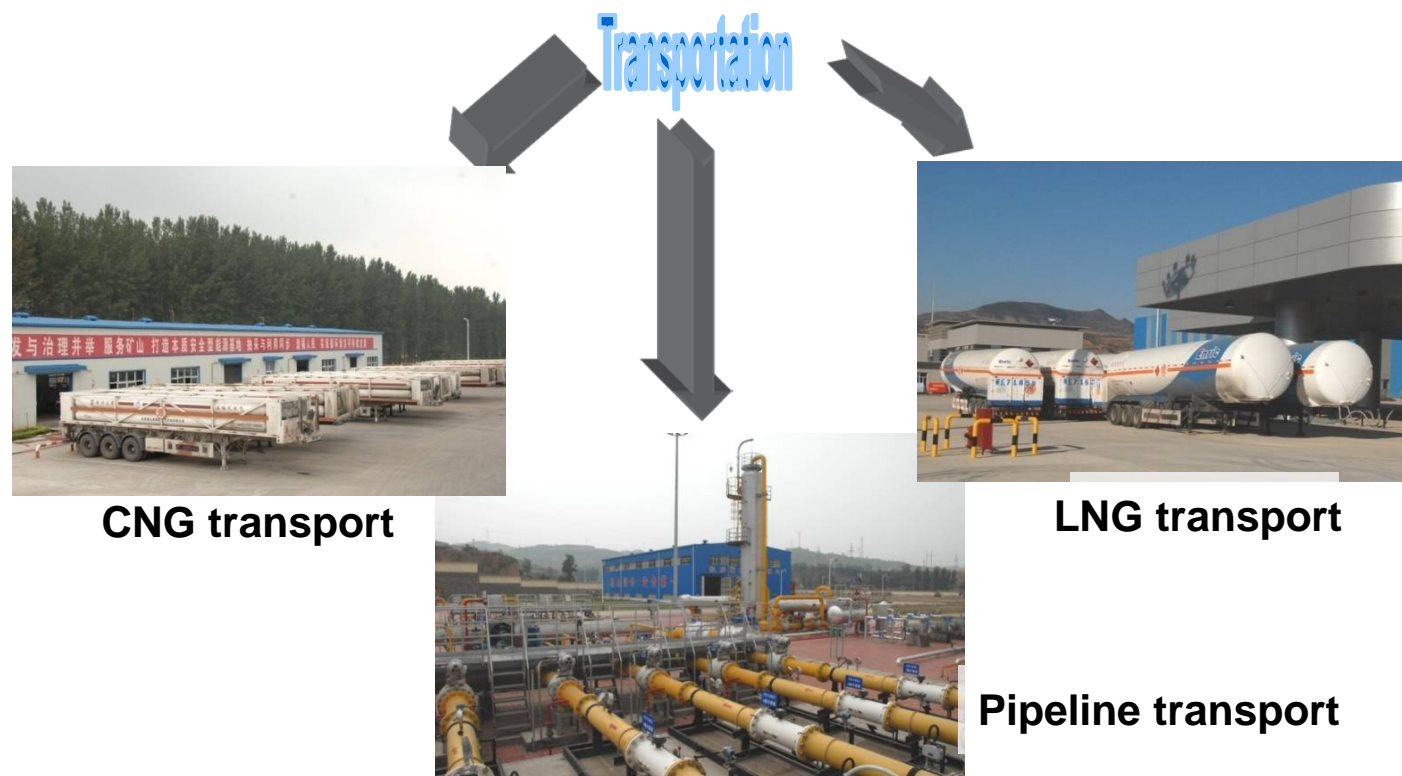


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IV. JAMG CBM Comprehensive Utilization Situations

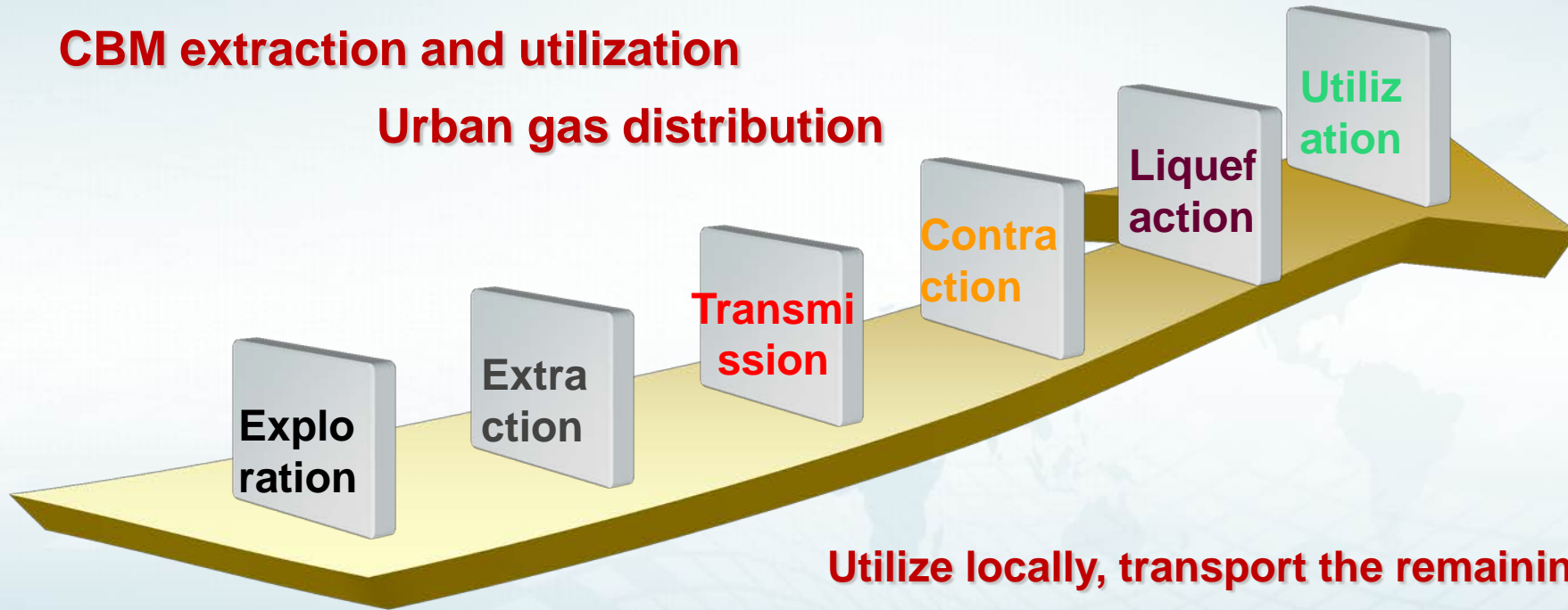
CBM comprehensive utilization of JAMG

Through over 20 years' construction and development, JAMG has constructed relatively complete CBM transmission (pipeline, LNG, CNG) and utilization (power generation, civil, industrial and vehicle) industrial chain. At present, there are totally 11000 employees.



CBM extraction and utilization

Urban gas distribution



- In recent ten years, accumulatively 14.047 Billion m³ CBM is extracted.
- Totally 8.418 Billion m³ CBM is utilized, forming the largest CBM utilization market in China

CBM power generation



120MW gas power generation plant



Gas power generation unit

- Form gas power generation cluster with total installed units of 101 sets and installed capacity of 199MW
- Annual utilization of low concentration CBM is **350 million m³**

- **Covering Taiyuan, Jincheng, Changzhi, Jinzhong and Linfen**
- **Fuel gas users reached over 1 million households**



Construct fuel gas network covering each municipality and county of Shanxi Province , which can meet gas demand of urban population no lower than county in the entire province.

Auto fuel



- Totally **24** CBM stations are built in Shanxi and Henan
- Over 300 special tank truck for CBM transportation, over 20,000 gas fuel and dual-fuel vehicle users



Plan to construct **100**
gas station in Shanxi
Province



- Provide clean fuels such as CBM and natural gas to over 3300 industrial users such as ceramics, glasses and iron enterprises
- Create **magnesium metal processing base**, and realize CBM local transformation and utilization



CBM liquidation plant



CBM contraction

- LNG productivity of Shanxi Yigao and Tianyu reached **1.2 million** m³/day, and products have been sold to Shanxi, Henan, Hebei, Jiangsu, Zhejiang, Shanghai, and Guangdong
- CNG productivity reached 1 million m³/day

In later production practices, we will actively refer to advanced experiences of overseas companies, combine industry-university-research, actively probe new model and applicable safe, effective and coordinated mining technology of coal and CBM, and strive to make larger contribution for healthy development of coal industry and CBM industry in China.

